COMPARISON OF FINANCIAL INVESTMENTS AND RETURN ON CAPITAL IN THE MINING INDUSTRY OF DEVELOPING COUNTRIES

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE

REQUIREMENTS FOR THE DEGREE OF

BACHELOR OF TECHNOLOGY

IN

MINING ENGINEERING

DEPARTMENT OF MINING ENGINEERING

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By

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C E R T I F I C A T E

This is to certify that the thesis entitled **"COMPARISON OF FINANCIAL INVESTMENTS AND RETURN ON CAPITAL IN THE MINING INDUSTRY OF DEVELOPING COUNTRIES"** submitted by **Sri Abhishek Nanda** in partial fulfillment of the requirements for the award of Bachelor of Technology Degree in Mining Engineering at the National Institute of Technology, Rourkela is an authentic work carried out by him under my supervision and guidance.

To the best of my knowledge, the matter embodied in the thesis has not been submitted to any other University/Institute for the award of any Degree or Diploma.

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DATE: **Abhishek Nanda (107MN025)**

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ABSTRACT

Mining is one of the most important industries in our society and has been there for ages. The resources extracted from the earth are fundamental in providing us with the quality of life we enjoy each day from the cars we drive to our cell phones we use. The food we eat is produced and harvested by machinery formed out of metals and mineral resources. The clothes we wear are treated and coated with dyes created from a variety of elements. Some fabrics are completely constructed from mined substances. It is not surprising to see that mineral resources have been widely spread throughout the world in almost every continent. Economical extraction and optimum use of these resources is what is essential to every country in its development.

For a country to effectively mine its natural resources is one of its biggest assets. In this age when every item seems to be linked to mining directly or indirectly a country's mineral wealth is far more valued above everything else. And as we read this not only the developed countries but also the developing countries are in the forefront of the mining industry. Small-scale mining is expanding rapidly and is uncontrollable in many developing countries. Slowly this small scale mining is turning into a full-fledged industry. Around 90 million people worldwide depend for their livelihoods on the often scant proceeds of mining.

Several factors such as market liberalization and the privatization of state-owned companies, the privileged access of local companies to significant and underdeveloped local resources, the strong financial positions due to the mining boom of 2003-2008, the drive for geographic and commodity diversification and also strategic expansion have led to this significant expansion of this industry in developing countries.

An effective comparison should be made between among the developing countries as far as the mining sector is concerned as far as the mining sector is concerned. This will effectively help to rank and index them according to their contribution and benefit from the mining sector. Many factors ranging from financial to social have an impact on this however for the simplicity of the matter it is best to restrict ourselves to financial constraints only.

Keywords: Mining, Developing, Financial, Capital

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Chapter 1

INTRODUCTION

1.1 NATURAL RESOURCES

Natural resources refer to mining, oil, gas and other natural resources. However many people see mining in a different light altogether from the other natural resources. Most studies examining the impact of natural resource sectors on industries and countries such as mining on economic growth look jointly at mining as well as at oil and gas. Some of the countries have sizable oil or gas resources. In most cases oil and gas are excluded from studies related to mining because of the following reasons:-

- The size of oil and gas sector in a country having those resources is much larger as compared to the mining sector of that economy.
- The structure of a value chain in mining typically involves a longer exploration period, a longer lead time between the construction and production, and a totally different effect in terms of the environmental, social, and economic changes in a region. These factors influence the flow of cash and revenues normally paid to governments by mining companies. Thus the share of mining in a country is completely different as compared to the oil and natural gas sector of that country.
- Moreover the extreme social and political dynamics involved in mining, in particular underground mining, differ from those in oil and gas. Many countries such as China, Poland, Romania, and Zambia have major political changes influencing the participation of mining companies in the industry. While mining can cause social disturbance it can also at times bring together the society. This can really be an important factor when it comes to the dynamics of the political economy of a mining country, rarely seen in oil and gas countries.

Much was made during the 2003-2008 mineral price boom that took place regarding the growing role of emerging market and developing country economies (henceforth emerging economies) in the global demand for minerals. However, it is so that of no lesser significance was the growing role played by these economies on the supply side. The contribution of the emerging economies to the worldwide supply of minerals since 2000 is striking. With their growth in production exceeding that of the advanced economies in almost every commodity, the share of these countries in global mineral production mounted steadily.

1.2 COAL

When it comes to talking about mineral resources one can arguably say that coal is probably the most important of them all. The reason is simple enough. The uses of coal in different aspects of life are numerous and one can readily recognize its importance. Coal is and has always been primarily used as a solid fuel to produce electricity and heat through combustion. Other efficient ways to use coal are combined heat and power generation. An even more efficient way of using coal for producing electricity is through the process of solid-oxide fuel cells or molten-carbonate fuel cells. Coal gasification with water and carbon sequestration are also processes that are catching up with other methods of energy production and efficiency.

However why should all this technology be limited to the developed countries. Developing countries too are making use of the above mentioned technologies. However the above will be possible only if enough importance is given to the exploration and expansion of the mining industry of the country. As we can see if a single substance like coal is capable of supporting and improving human life in so many ways what are the possibilities that the other minerals may throw at us. We shall focus our study and analysis on the coal mining sector of the countries taken for the assessment. Since coal has the uses mentioned above and many more it was a unanimous opinion to represent this as the mineral involved in the study when it comes to mining. Hence keeping this in mind care has been taken that only such countries are chosen for comparison which produce coal in some quantity or other.

At a time when the entire world faces the challenge of global warming it has become essential to find fuels that are renewable in nature and are more energy efficient as compared to coal and other natural resources. But in spite of this the entire world still depends on traditional resources like coal and oil. With proved reserves equivalent to more than 125 years at the present rate of extraction coal seems like an especially secure energy. Between 1995 and 2005, the world's total output of primary energy --increased at an average annual rate of 2 %. World coal production increased from 373 quadrillion British Thermal Unit (Btu) in 1996 to 469 quadrillion Btu in 2006 [1].

Coal ranked second as a primary energy source in 2006, accounting for close to 28 percent of world primary energy production. The World coal production added up to 130 quadrillion Btu, in 2006, and it increased by 32.7 percent from the 1996 level of 5.1 billion short tons. According to a statement issued by the IEA in its World Energy Outlook 2009, the consumption of coal is expected to rise by 1.9% per year between now and 2030.

We had proved coal reserves at year-end 2008 standing at an estimated 826 billion tons, representing about 122 years of production at the current rate. Coal is by far the most broadly distributed energy in the world. One-third of the world coal reserves are located in North America (30%), primarily in the United States; one-third in parts of Europe and Asia (33%), and one-third in Asia-Oceania (30%), where the reserves in China are equal to the sum of the total reserves in both India and Australia. Africa on the other hand represents less than 5% of the total. In this continent the bulk of the coal wealth is found in South Africa. The main coal giants are China, Indonesia, Canada, USA, India, etc.

Table 1.1: Top Ten Hard Coal Producers (2009)

Country	**Coal Production (Mt) (2009)**
PR China	2971
USA	919
India	526
Australia	335
Indonesia	263
South Africa	247
Russia	229
Poland	96
Kazakhstan	78
Colombia	73

In more than 100 countries around the world, mining companies and individual miners dig minerals and metals out of the ground, satisfying a slowly but continuously increasing demand from industrial production and various other utility industries. More than 50 countries can be considered as mining countries well known for this sector's contribution to export earnings. These countries include Australia, Botswana, Chile, Canada, Guinea, Kazakhstan, Papua New Guinea, Peru, and South Africa. Mining countries also include those where this sector is highly relevant domestically. This means that the industry either serves large domestic markets else employs a large percentage of the country's population (China and India).

90 percent of the 3.6 billion people of the 56 mining countries live in the 51 developing and transition countries. Their countries have potential wealth – mineral wealth – and thus one of the key questions for them is how they can turn this into an economic asset and strength [2]. There is no doubt that the mining industry will continue to boom for the next 50 years or so. What remains to be seen is that whether the developing countries are capable of utilizing these resources for their overall economic and social development. The natural resources that have been endowed to them are capable of boosting their economy and bringing them into the energy race along with other developed countries.

1.3 GLOBAL MINING INDUSTRY IN PERSPECTIVE

In the year 2009 the global mining industry experienced rapid recovery of market capitalization. The market capitalization of the Top 40 increased $696 billion, reaching levels just below the peak prior to the financial crisis. The recovery has largely been driven by a sharp revitalization in prices during 2009 and an overall improved investment climate [3]. In comparison to the previous year, the market capitalization cut-off for inclusion increased to levels similar to those seen in the second half of 200. This has increased from $2.5 billion in 2008 to around $7 billion in 2009.

1.4 OBJECTIVES

The objectives of this project are clearly outlined below:-

- To implement Analytic Hierarchy Procedure (AHP) for assigning different weights to the different parameters chosen for the comparison.
- To normalize the parameters and obtain a eigenvector value for easier calculations for variables which do not have an exactly numerical consequence.
- Calculation of points for each parameter and summing them to get an index which gives a comparison.
- To forecast the production, consumption and exports figures of the coal industry of a few countries.
- To calculate the returns on their capital investment using the AHP model and earnings via exports.

Chapter 2

LITERATURE REVIEW

To make a comparative study of the different coal producing countries we have to take a list of parameters. A total of six factors have been identified and these will be used to carry out and map a comparative analysis.

- Gross Domestic Product(GDP)
- Mining Contribution to GDP
- Workforce employed in the Mining Industry
- Annual Production
- Exports
- Current Reserves

2.1 Gross Domestic Product (GDP)

Gross Domestic Product (GDP) is one of the primary indicators used to measure the health of a country's economy. Usually, GDP is expressed as a comparison to the previous quarter or year. For example, if the year-to-year GDP is up 5%, this is thought to mean that the economy has grown by 5% over the last year. It also refers to the market value of all final goods and services produced within a country in a given period. It is often considered an indicator of a country's standard of living. Gross domestic product is related to national accounts, a subject in macroeconomics. The expenditure method of calculating GDP gives the formula for calculating GDP as

$$GDP = \text{private consumption} + \text{gross investment} + \text{government spending} + (\text{exports} - \text{imports})$$

GDP can be stated as *GDP* per capita (per person) in which total GDP is divided by the total resident population on a given date. We use GDP/capita for our comparison in the following sections.

2.2 Mining Contribution to GDP

The contribution of the mining industry to the GDP is expressed as a % of the total GDP. The industrial components of the GDP are necessary and hence the mining contribution has to be taken into account regarding this. The mining contribution to GDP of a particular country varies taking into account the relative size of the industry in that particular country. For example in Australia the mining sector nearly accounts for 7% of the GDP.

2.3 Coal Exports

In many cases we see that the primary coal producing countries export coal. This can be due to a variety of reasons. It could be due to the quality of coal produced or the amount of coal produced. E.g. Indonesia in 2008 exported 160.27 Mt of its total production of 233.62 Mt of coal and this grew up to 230 Mt in 2009 [4].

Table 2.1: Top Coal Exporters (2009)

Country	Exports (Mt) (2009)
Australia	259
Indonesia	230
Russia	116
Colombia	69
South Africa	67
USA	53
Canada	28

2.4 Current Reserves

Proved coal reserves at the end of 2008 were an estimated 830 billion tons, representing about 120 years of production at the current rate. According to WEC survey data for about 60-70 countries, world coal reserves are concentrated in thirds. South America holds only 2% of world reserves. At current production levels, proven coal reserves are estimated to last 119 years. In contrast, proven oil and gas reserves are equivalent to around 46 and 63 years at current production levels respectively. Over 62% of oil and 64% of gas reserves are concentrated in the Middle East and Russia.

2.5 Industry Employment

Employment in the mining industry is the backbone of the workforce in many countries. Residents of mining extensive regions and countries look forward to this industry as their bread and butter and it forms an important source of employment. While employment in the new operation is the main objective of the locals, indirect employment effects are often extremely important. Employment in subcontracted firms that supply mine goods and services is often equal to or much higher than direct mine employment.

2.6 Coal Production

A 2010 BP Statistical Energy Survey states that there are 826001 million tonnes of coal reserves left in the world as of 2009. At a current production and consumption rate these resources would last close to 119 years. The world's largest reserves are held by the USA, Russia, China, Australia and India. The coal production in 2009 stood at 6940.57 million tonnes. The major producers were China, India, USA, Australia, Indonesia, South Africa, etc. the consumption in 2009 stood at 3278.3 million tonnes. Out of this China alone accounted for nearly 50% of the world coal consumption.

2.7 Multi-Attribute Decision Models

Multi Attribute Decision Models are useful in solving complex decision making problems using different criteria by networking them into hierarchies and network trees. These models are widely used in situations when one is not able to comprehend and allocate numerical values to rational problems. Such models thereby help us in differentiating between varieties of decisions and hence chart the problem using different combinations of decisions.

Decision models are an essential part of decision analysis. Usually a lot of effort is dedicated to the construction of a suitable and useful model. Expert knowledge and data that describes the decision problem or known solutions are carefully combined into a model. The use of the model depends on the characteristics of decision problem [5]. Some models are used only once, when a difficult decision has to be thoroughly analyzed. Most of the models that are used continuously have to be regularly revised to reflect the new state of decision problem as well as possible.

Building a model is a demanding, time consuming and expensive process. Revising an existing one is not much easier. Although the actual changes in the model are usually minor, this process requires: gathering new data, the evaluation of changes and their effect, reimplementation of decision support tools and verification of the new behavior.

"Decision making is the study of identifying and choosing alternatives based on the values and preferences of the decision maker. Consider a multi-attribute decision making problem with *m* criteria and *n* alternatives. Let **C**1,.,**C***m* and **A**1,..,**A***n* denote the criteria and alternatives, respectively. A standard feature of multi-attribute decision making methodology is the *decision table* as shown below. In the table each row belongs to a criterion and each column describes the performance of an alternative." [6]

The score *aij* describes the performance of alternative **A***j* against criterion **C***i*. For the sake of simplicity we assume that a higher score value means a better performance since any goal of minimization can be easily transformed into a goal of maximization. They represent the opinion of a single decision maker or synthesize the opinions of a group of experts using a group decision technique, as well. Usually, higher ranking value means a better performance of the alternative, so the alternative with the highest ranking value is the best of the alternatives [7].

Multi-criteria decision making has been one of the fastest growing areas during the last decades depending on the changings in the business sector. Decision maker(s) need a decision aid to decide between the alternatives and mainly excel less preferable alternatives fast [8].

$$\begin{array}{c|l|}
 & A_1 \quad . \quad . \quad . \quad . \quad A_n \\
\hline
C_1 & a_{11} \ldots\ldots\ldots\ldots a_{1m} \\
. & . \\
. & . \\
C_m & a_{m1} \ldots\ldots\ldots\ldots a_{mn} \\
\hline
\end{array}$$

Multi-attribute decision making techniques can partially or completely rank the alternatives: a single most preferred alternative can be identified or a short list of a limited number of alternatives can be selected for subsequent detailed appraisal. Besides some monetary based and elementary methods, the two main families in the multi-attribute decision making methods are those based on the Multi-attribute Utility Theory (MAUT) and Outranking methods.

Chapter 3

CONCEPT OF AHP

3.1 Analytic Hierarchy Process

The Analytic Hierarchy Process (AHP) is a concise and general problem-solving method that is useful in making complex decisions based on variables that do not have exactly numerical consequences. Large scale decision models are encountered by people in real life. Such situations pose difficult decisions to be taken and hence it is essential to develop a kind of multi attribute decision model which helps to model complex decisions with reasonable accuracy and practicability. Analytic hierarchy process (AHP) is such a multi-attribute decision-making (MADM) technique [9], first developed in 1980 by Thomas L. Saaty.

It is basically a tool to combine qualitative and quantitative factors in the selection of a process and is used for assigning priorities in a complex situation. AHP provides an easy and flexible to understand way of analyzing complicated problems. Hence AHP gives decision makers a rational basis for decision-making. It has become quite popular in research because its utility outweighs other rating methods. The AHP technique has been accepted by the international scientific community as a robust and flexible multi-criteria decision-making tool for dealing with complex decision problems.

Three features of AHP differentiate it from other decision making approaches:

(i) its ability to handle both the real and unreal attributes of a problem,
(ii) its ability to structure and model the problems in a hierarchical networked manner and hence gain insights into the decision making process, and
(iii) its ability to monitor the consistency of the comparisons with which a decision maker uses his/her judgment regarding the problem.

In AHP we first decompose the decision problem into a hierarchy of more easily understandable sub-problems each of which can be analyzed separately. The elements of the hierarchy can relate to any aspect of the decision problem.

Once the hierarchy has been established decision takers will evaluate and allocate pairwise comparisons to the different parameters with respect to the attributes above the hierarchy. In making the comparisons, the decision makers can use concrete data about the elements, or they can use their judgments about the elements' relative meaning and importance. The essence of the AHP lies in the fact that human judgments are used in performing the evaluations. The AHP converts these evaluations to numerical values that would not have been otherwise possible and thus it can now be processed and compared over the entire range of the problem. This capability distinguishes the AHP from other decision making technique.

3.2 THE AHP THEORY

Let us consider n elements to be compared, $M_1 \ldots M_n$ and denote the relative 'weight' (or priority or significance) of M_i with respect to M_j by a_{ij} and form a square matrix A= (a_{ij}) of order n with the constraints that $a_{ij} = 1/a_{ji}$, for $i \neq j$, and $a_{ii} = 1$, all i. Such a matrix is said to be a reciprocal matrix. The weights are consistent if they are transitive, that is $a_{ik} = a_{ij}a_{jk}$ for all i, j, and k. Then find a vector ω of order n such that $A\omega = \lambda\omega$. For such a matrix, ω is said to be an eigenvector (of order n) and λ is an eigenvalue [10]. For a consistent matrix, $\lambda = n$. For matrices involving human judgement, the condition $a_{ik} = a_{ij}a_{jk}$ does not hold as human judgements are inconsistent to a greater or lesser degree. In such a case the ω vector satisfies the equation $A\omega = \lambda max \omega$ and $\lambda max \geq n$. The difference, if any, between λmax and n is an indication of the inconsistency of the judgements. If λmax = n then the judgements have turned out to be consistent.

Finally, a Consistency Index can be calculated from (λmax-n)/ (n-1). That needs to be assessed against judgments made completely at random and Saaty has calculated large samples of random matrices of increasing order and the Consistency Indices of those matrices. A true Consistency Ratio is obtained by dividing the Consistency Index for the total set of judgments by the Index obtained for the corresponding random matrix. Thomas suggests that if that ratio exceeds 0.1 the set of judgments considered may be too inconsistent to be reliable and praticable. In practice, CRs of more than 0.1 sometimes have to be accepted. A CR of 0 means that the judgements are perfectly consistent.

The following table is used to determine the relative importance of one parameter vs the other when it comes to assigning pairwise combinations.

Table 3.1: The Saaty Rating Scale

Intensity of Importance	Definition	Explanation
1	Equal Importance	Two factors contribute equally to the objective
3	Somewhat more important	Experience and judgement slightly favour one over the other.
5	Much more important	Experience and judgement strongly favour one over the other.
7	Very much more important	Experience and judgement very strongly favour one over the other. Its importance is demonstrated in practice.
9	Absolutely more important	The evidence favouring one over the other is of the highest possible validity.
2,4,6,8	Intermediate Values	When compromise is needed

A comparison matrix is set up by comparing pairs of criteria or alternatives. A scale of values ranging from 1 (equally important) to 9 (extreme more important) was used to express evaluators' preferences. This pairwise comparison enables the decision maker to measure the contribution of each factor to the objective independently, thereby simplifying the decision-making process. The final step synthesizes priorities to calculate a composite weight for each alternative, based on preferences derived from the comparison matrix.

The eigenvector calculations are one of the most important steps of the process as they give the normalized weights.

Step1 – Multiply the entries of each row of the matrix.

Step2 – Take the n^{th} root of the product.

Step3 – The n^{th} roots of all the rows are summed and that sum is used to normalize the eigenvector elements to add to 1.

Step4 – Calculate the consistency ratio (CR) and consistency index (CI) if required by multiplying the right matrix of the judgements of the eigenvector hereby obtaining a new vector.

Table 3.2: Consistency Table

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0.00	0.00	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49	1.51	1.48	1.56	1.57	1.59

Consistency Ratio (CR)

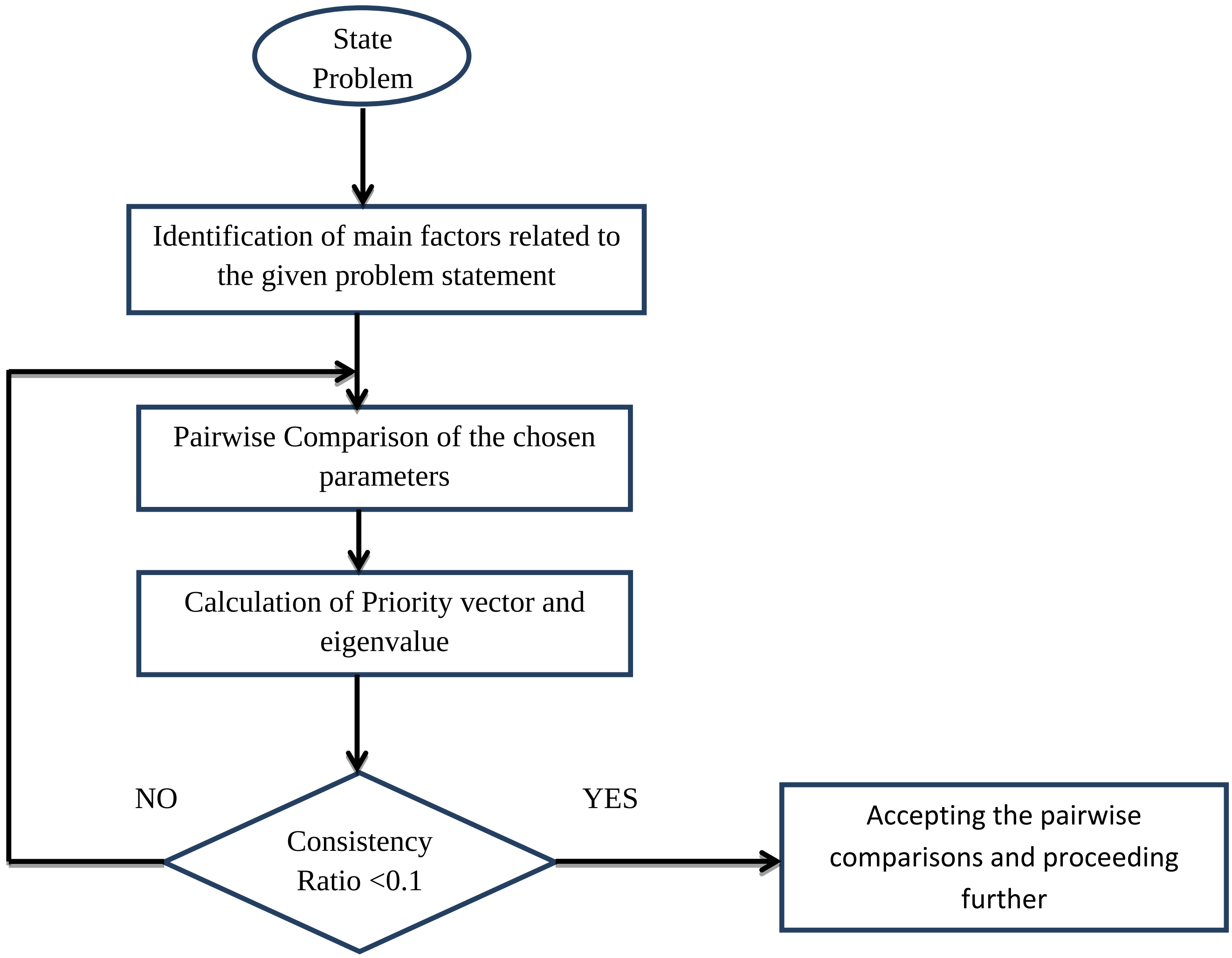
- < 0.1; trustworthy
- > ≈ 0.1; just accepted
- ≈0.8-0.9 completely untrustworthy

The Consistency Index for a matrix is calculated from (λ_{max}-n)/ (n-1). The last step is to calculate the Consistency Ratio for the set of judgements using the CI for the corresponding value from large samples of matrices of purely random judgments using the table given above. The upper row is the order of the random matrix, and the lower is the corresponding index of consistency for random judgements.

3.3 STRENGTHS AND WEAKNESSES OF THE AHP

Like all other modelling methods, the AHP too has strengths and weaknesses. The main advantage of the AHP is in its ability to rank choices in the order of their effectiveness in meeting conflicting objectives. If the judgements made about the relative importance of each other, have been made in good faith, then the AHP calculations lead inexorably to the logical consequence of those judgements. It is quite hard but not impossible to tamper the judgements to get some predetermined result. The strength of AHP lies in its ability to detect inconsistent judgements. The limitations of the AHP procedure are that it only works because the matrices are all of the same mathematical form – known as a positive reciprocal matrix. To create such a matrix requires that, if we use the number 9 to represent ‘A is absolutely more important than B’, then we have to use 1/9 to define the relative importance of B with respect to A. Some people regard that as reasonable; others are less happy about it.

The other drawback is, that if the scale is changed from 1 to 9 to, say, 1 to 25 or 27, the numbers in the end result will also change. Changing of scale is sometimes both for better and for worse as the results get skewed later on and hence might not agree with the actual practicalities of the problem considered.



Chapter 4

COMPARISON & RATING

To compare and rank a few countries have been taken into account. It should be noted that of the 4 countries considered 3 are developing countries whereas the 4th one is a developed country. This has been done to show the marked difference in the points obtained for each of the countries and hence proving that the results obtained hereby are correct. Developed countries will tend to show a greater points total by this method as their respective figures for the different parameters will be different (higher as compared to developing countries) and hence the difference in the overall result. Below are discussed the countries that have been taken into account and a brief idea about their economies particularly the advancements in their mining sectors. The parameters to be considered have already been discussed above and hence will not be repeated again.

The developing countries that have been opted for this study are ***Poland, South Africa*** and ***Indonesia***. The developed country that forms a basis for comparison is ***Canada***.

4.1 Canada

Canada is a mid-size coal producer and is ranked the 14th among global coal producing countries. Canada's coal production has remained relatively steady over the past decade. About 60% of the coal production was thermal coal and 40% was metallurgical (coking) coal. Thermal coal production is mainly for domestic consumption. Coal is primarily consumed for electricity generation. Canada has been an active player in the coal mining industry for decades now. Most of the exports of Canada include coking coal. The thermal coal production is primarily for the purpose of domestic consumption. The coking coal that Canada exports are one of finest quality and hence it is one of the world's leading coking coal suppliers. Coal Association of Canada is an industry organization. British Columbia leads the Canadian province as far as the mining sector is concerned.

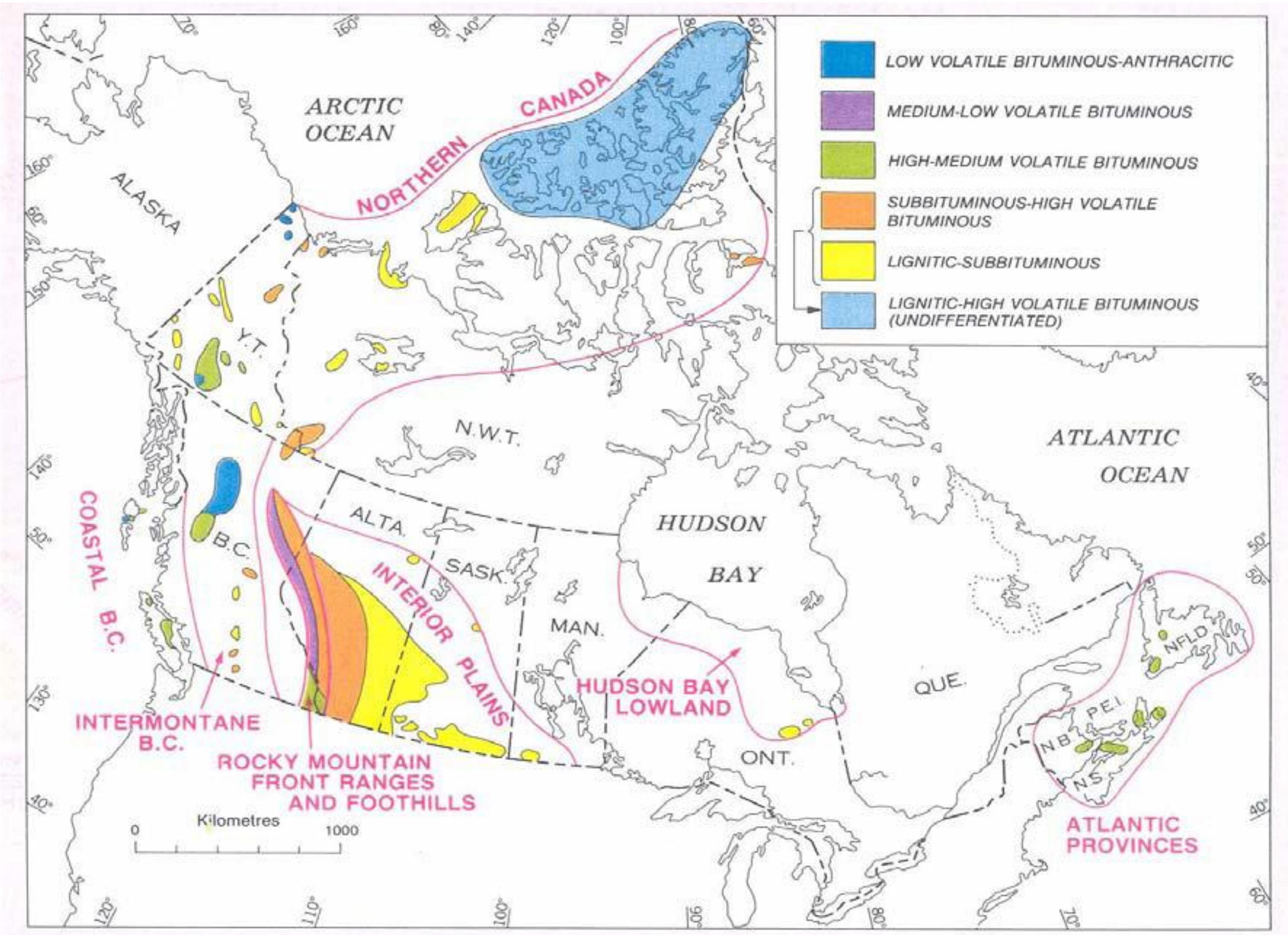


Figure 1.1. Distribution of coal in Canada.

Figure 4.1: Distribution of Coal in Canada

The mining industry remains a foundation of the Canadian economy. It contributes around $48 billion to the country's GDP, employs 350,000 people, pays about $13.8 billion in taxes and royalties, accounts for 19.2 % of Canada's exports and generates business for 3,200 supplier companies [11].

The Canadian mining industry accounts for 19% of all exports of Canadian goods, 12% of Canada's stock of direct investment abroad and some 60% of the world's mineral exploration companies. Canada's coal production has remained relatively steady over the past decade. In 2007, Canada produced 70 million tonnes of coal valued at C$2.7 billion.

Table 4.1: Values of Parameters of Canada

Parameter	Value	Units
GDP	US $1.34 Trillion	--
GDP/Capita	US$39,033	
Mining Industry Contribution to GDP	US $46.9 Billion	--
Industry Employment	--	3,50,000
Coal Exports	--	27.2 Mt
Current Reserves	--	6578 Mt
Coal Production	--	62.93 Mt

4.2 Indonesia

Indonesia is world's second largest exporter of coal. It has continued to boost its coal exports to meet the growing demand of coal in the world market. It has now become the second largest supplier of this mineral to the world market after country Australia. However it ranks only the 7th in production. The proven reserves shot up to 18.8 billion tons in the year 2009 as a result of explorations boosted by the rise in coal prices.

The 2010 BP Statistical Energy Survey states that Indonesia had 2009 coal reserves of 4328 million tonnes constituting 0.52% of the world total. Indonesia had 2009 coal production of 252.47 million tonnes, 4.55% of the world total. Indonesia adopted a National Coal Policy in 2004, which seeked to promote the development of the country's coal resources to meet domestic requirements and to increase coal exports [12]. The state-owned PT Tambang Bukit Asam is one of the five largest coal producers in Indonesia. Almost a quarter of its production is exported to international markets, including Japan, Taiwan, Malaysia, Pakistan, Spain, France and Germany. The company has mineable reserves of approximately 7.3 billion tons or 17% of the total coal reserves in Indonesia.

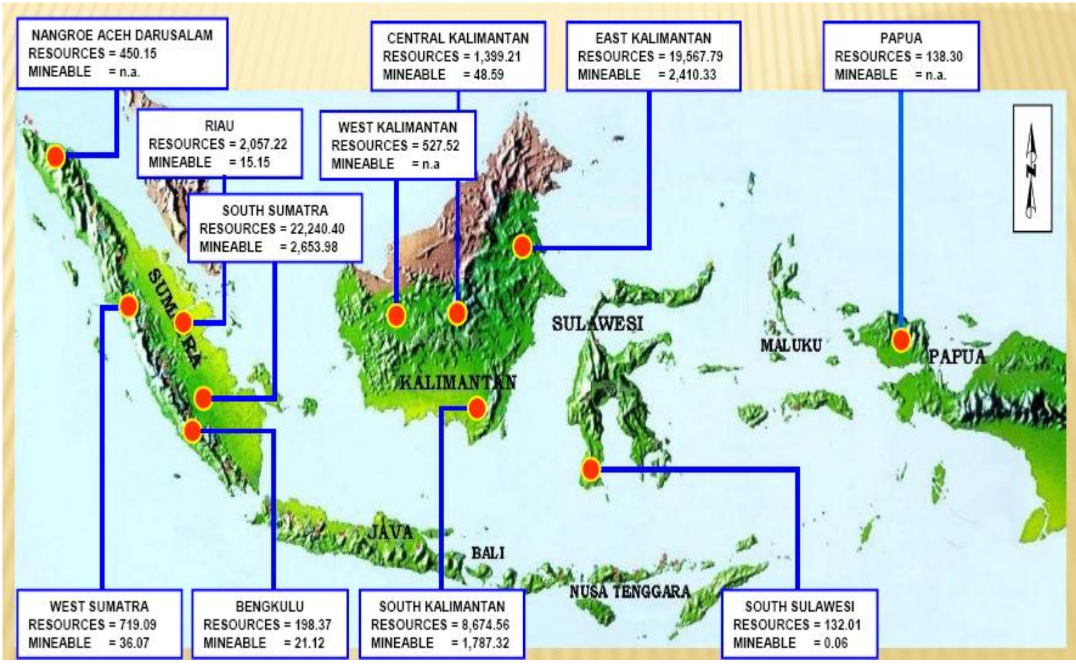


Figure 4.2: Distribution of Coal in Indonesia

Table 4.2: Values of Parameters of Indonesia

Parameter	**Value**	**Units**
GDP	US $1.033 Trillion	--
GDP/Capita	US $4380	
Mining Industry Contribution to GDP	US $10 Billion	--
Industry Employment	--	85,400
Coal Exports	--	160.27 Mt
Current Reserves	--	17.05 Bt
Coal Production	--	233.62 Mt

4.3 POLAND

According to the 2010 BP Statistical Energy Survey, Poland had 2009 coal reserves of 7500 million tonnes around 1% of the world total. Poland had 2009 coal production of 135.14 million tonnes, 1.65% of the world total. It had coal consumption of 53.85 million tonnes oil equivalent, 1.64% of the world total. Poland is one of the largest consumers and producers of coal in Europe.

According to the 2008 BP Statistical Energy Survey, Poland had end 2007 coal reserves of 7502 million tonnes. Coal exports are one of Poland's largest foreign income earners through exports to Europe and the Former Soviet Union (FSU). Coal is the dominant fuel in the region but is declining in market share. According to the 2008 BP Statistical Energy Survey, Poland had 2007 coal production of 145.76 million tonnes and consumption of 57.13 million tonnes oil equivalent. Coal recently accounted for 93% of the country's primary energy production and over 70% of total consumption [13].

Figure 4.3 Distribution of Coal in Poland

Table 4.3: Values of Parameters of Poland

Parameter	Value	Units
GDP	US $721.026 Billion	--
GDP/Capita	US $18,837	--
Mining Contribution to GDP	US $23 Billion	--
Industry Employment	--	1,19,000
Current Reserves	--	7.5 Bt
Total Production	--	135.14 Mt
Coal Exports	--	94 Mt

4.4 South Africa

Mining in South Africa has always been the main driving force behind the history and development of Africa's most advanced and richest economy. South Africa is one of the seven largest coal-producing countries in the world. South Africa is currently the world's third largest coal exporter, and much of the countries' coal is used for power production (about 40%). Open-pit mining account for roughly half of South African coal mining operations, the other half being sub-surface. It contributed about 19% of GDP (8.8% directly); over 50% of merchandise exports (if secondary beneficiated mineral exports are added); about 1 million jobs (about 500 000 jobs indirectly); about 18% of gross investment (10% directly); approximately 30% of capital inflows into the economy via the financial account of the balance of payments. The rate of growth in real mining fixed investment dropped considerably from 27.7% growth in 2007, 13.2% growth in 2008 to only 2.7% growth in 2009 [14].

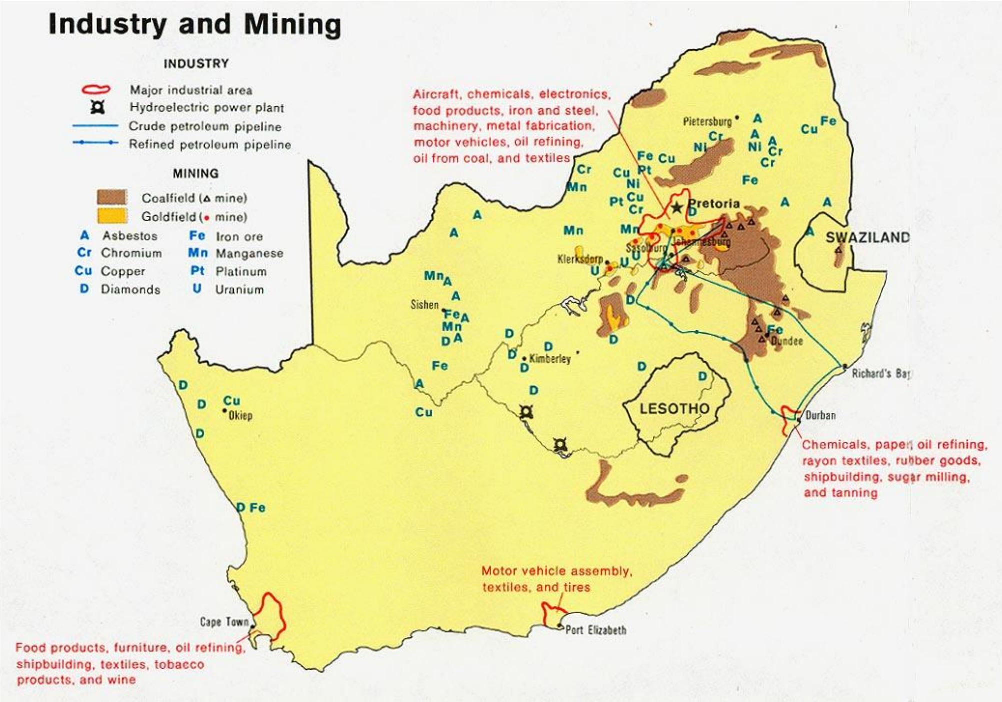


Figure 4.4: Distribution of Coal in South Africa

Table 4.4: Values of Parameters of South Africa

Parameter	**Value**	**Units**
GDP	US $525.05Billion	--
GDP/Capita	US $10,707	--
Mining Contribution to GDP	US $42.2 Billion	--
Industry Employment	--	4,93,000
Current Reserves	--	30.4 Bt
Total Production	--	250.02 Mt
Coal Exports	--	63.43 Mt

4.5 CALCULATION OF RELATIVE WEIGHTS

4.5.1 COUNTRY vs PARAMETERS

In this section we calculate the value of every country with respect to each other for each of the given parameters. A pairwise comparison assumption is taken and the relative weights and eigenvector values are calculated. Any discrepancy of faulty assumption can be checked for later on by checking the values of λ_{max}. It will be seen later on that a faulty assumption is encountered quite a number of times and hence for them a revised assumption is taken again.

4.5.1.1 GDP/Capita

Table 4.5: Country vs Country (GDP/Capita)

	Canada	Indonesia	Poland	South Africa	Relative Weights	Eigenvectors M_i	λ_{max}
Canada	1	5	5	3	2.942	0.558	4.061
Indonesia	1/5	1	1	1/3	0.506	0.096	4.0211
Poland	1/5	1	1	1/3	0.506	0.096	4.0211
South Africa	1/3	3	3	1	1.316	0.249	4.044
Net Sum					5.27	0.9997	

Mean λ_{max} = 4.036

Consistency Index (CI) = (λ_{max}-n)/ (n-1) = 0.012

Consistency Ratio (CR) = 0.012/0.09 = 0.0133 which is < 0.1

Hence the pairwise judgements are trustworthy and accepted.

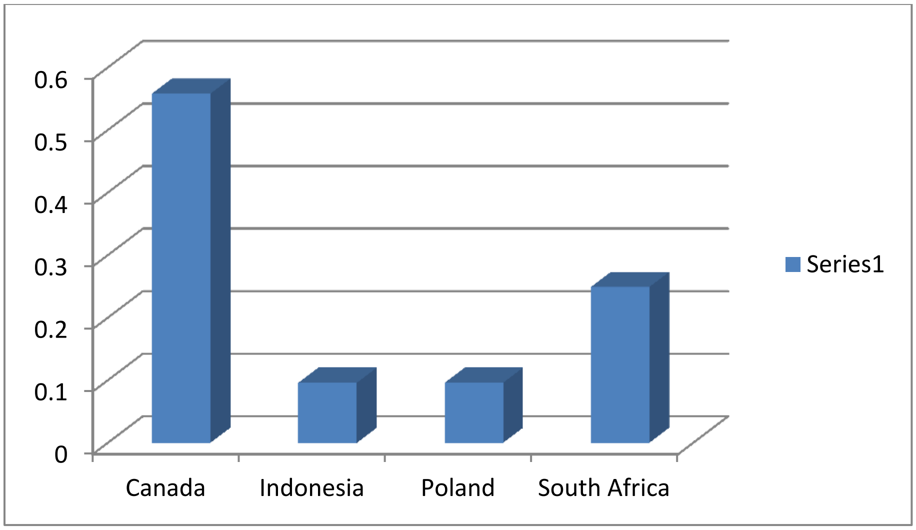


Figure 4.5: Graph of Country vs Country (GDP/Capita)

4.5.1.2 Mining Contribution to GDP

Table 4.6: Country vs Country (Mining Contribution to GDP)

	Canada	Indonesia	Poland	South Africa	Relative Weights	Eigenvectors M_i	λ_{max}
Canada	1	1/3	3	1/3	0.757	0.558	4.061
Indonesia	3	1	5	1	1.96	0.096	4.0211
Poland	1/3	1/5	1	1/3	0.384	0.096	4.0211
South Africa	3	1	3	1	1.7326	0.249	4.044
Net Sum					4.8336	0.9998	

Mean = 4.104

Consistency Index (CI) = (λ_{max}-n)/ (n-1) = 0.034

Consistency Ratio = 0.034/0.9 = 0.038 < 0.1

Hence the assumptions are considered trustworthy.

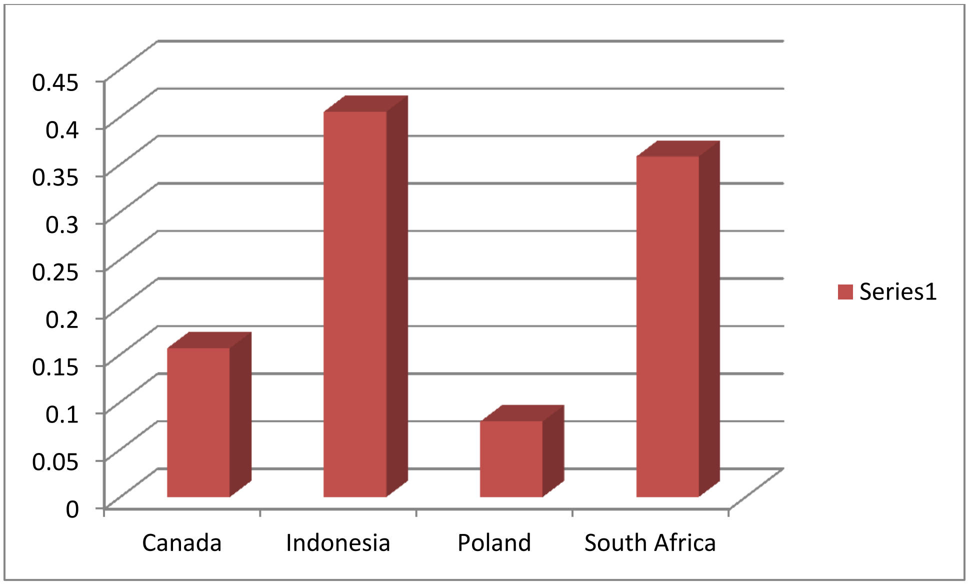


Figure 4.6: Graph of Country vs Country (Mining Contribution to GDP)

4.5.1.3 Coal Exports

Table 4.7: Country vs Country (Coal Exports)

	Canada	Indonesia	Poland	South Africa	Relative Weights	Eigenvectors M_i	λ_{max}
Canada	1	1/7	1/5	1/3	0.312	0.059	4.048
Indonesia	7	1	3	3	2.817	0.535	4.046
Poland	5	1/3	1	1	1.133	0.2153	4.079
South Africa	3	1/3	1	1	1.00	0.1900	4.098
Net Sum					5.262	0.9993	

Mean λ_{max} = 4.042

Consistency Index (CI) = (λ_{max}-n)/ (n-1) = 0.014

Consistency Ratio (CR) = 0.014/0.9 = 0.015 < 0.1

Hence the pairwise comparisons are trustworthy and accepted.

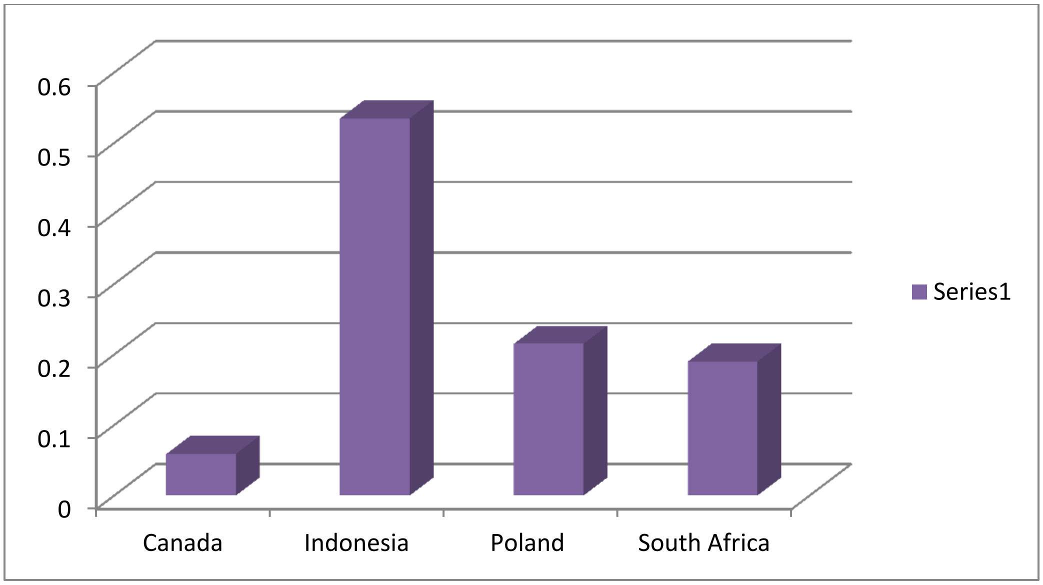


Figure 4.7: Graph of Country vs Country (Coal Exports)

4.5.1.4 Current Reserves of Coal

Table 4.8: Country vs Country (Current Reserves)

	Canada	Indonesia	Poland	South Africa	Relative Weights	Eigenvectors M_i	λ_{max}
Canada	1	1/3	1	1/7	0.467	0.085	3.97
Indonesia	3	1	3	1/3	1.316	0.239	
Poland	1	1/3	1	1/5	0.508	0.092	
South Africa	7	3	5	1	3.201	0.583	
Net Sum					5.492	0.9998	

The value 3.97 is < 4.00. Saaty's rule says that the eigenvectors should be greater than the order of the matrix in any case whatsoever. Hence since in this case the order of the matrix is 4 and the eigenvector obtained is 3.97 it is rejected and a new set of pairwise comparisons are chosen over the older set.

Table 4.9: Revised Country vs Country (Current Reserves)

	Canada	Indonesia	Poland	South Africa	Relative Weights	Eigenvectors M_i	λ_{max}
Canada	1	1/3	1	1/5	0.508	0.096	4.013
Indonesia	3	1	3	1/3	1.316	0.249	4.053
Poland	1	1/3	1	1/5	0.508	0.096	4.013
South Africa	5	3	5	1	2.942	0.557	4.068
Net Sum					5.274	0.998	

Mean λ_{max} = 4.036

Consistency Index (CI) = $(\lambda_{max}-n)/(n-1)$ = 0.012

Consistency Ratio (CR) = 0.012/0.9 = 0.013 < 0.1

Hence the pairwise comparisons are trustworthy and accepted.

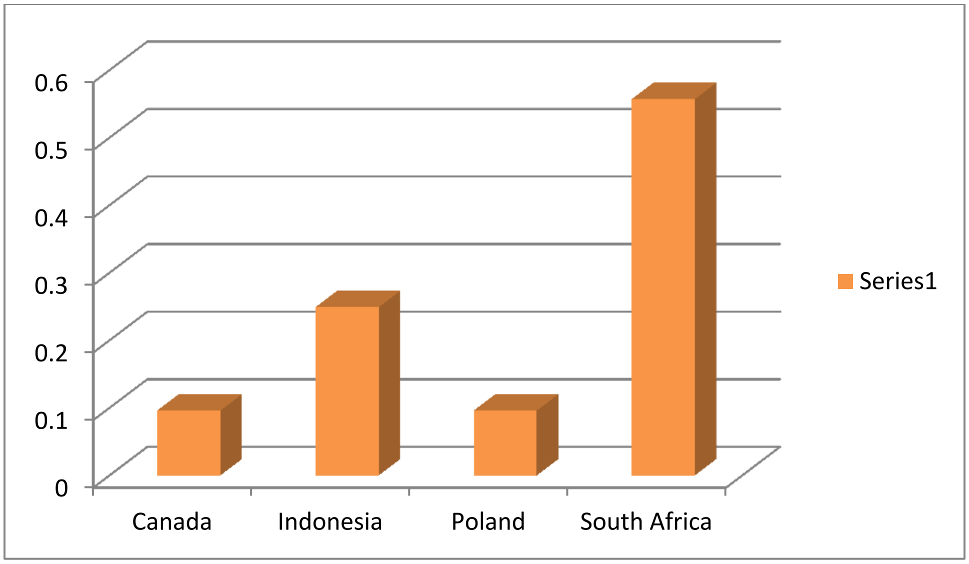


Figure 4.8: Revised Graph of Country vs Country (Current Reserves)

4.5.1.5 Industry Employment

Table 4.10: Country vs Country (Industry Employment)

	Canada	Indonesia	Poland	South Africa	Relative Weights	Eigenvectors M_i	λ_{max}
Canada	1	9	3	1	3.000	0.476	3.3
Indonesia	1/9	1	1/7	1/7	0.2182	0.034	
Poland	1/3	7	1	1/3	0.939	0.1491	
South Africa	1	7	3	1	2.140	0.339	
Net Sum					6.2972	0.999	

The value 3.3 is < 4.00. Saaty's rule says that the eignevectors should be greater than the order of the matrix in any case whatsoever. Hence since in this case the order of the matrix is 4 and the eigenvector obtained is 3.3 it is rejected and a new set of pairwise comparisons are chosen over the older set.

Table 4.11: Revised Country vs Country (Industry Employment)

	Canada	Indonesia	Poland	South Africa	Relative Weights	Eigenvectors M_i	λ_{max}
Canada	1	7	3	1	2.14	0.403	4.059
Indonesia	1/7	1	1/7	1/5	0.252	0.047	4.271
Poland	1/3	7	1	1/3	0.939	0.177	4.321
South Africa	1	5	3	1	1.967	0.371	4.160
Net Sum					5.298	0.998	

Mean λ_{max} = 4.202

Consistency Index (CI) = $(\lambda_{max}$-n)/ (n-1) = 0.067

Consistency Ratio (CR) = 0.012/0.9 = 0.07 < 0.1

Hence the pairwise comparisons are trustworthy and accepted.

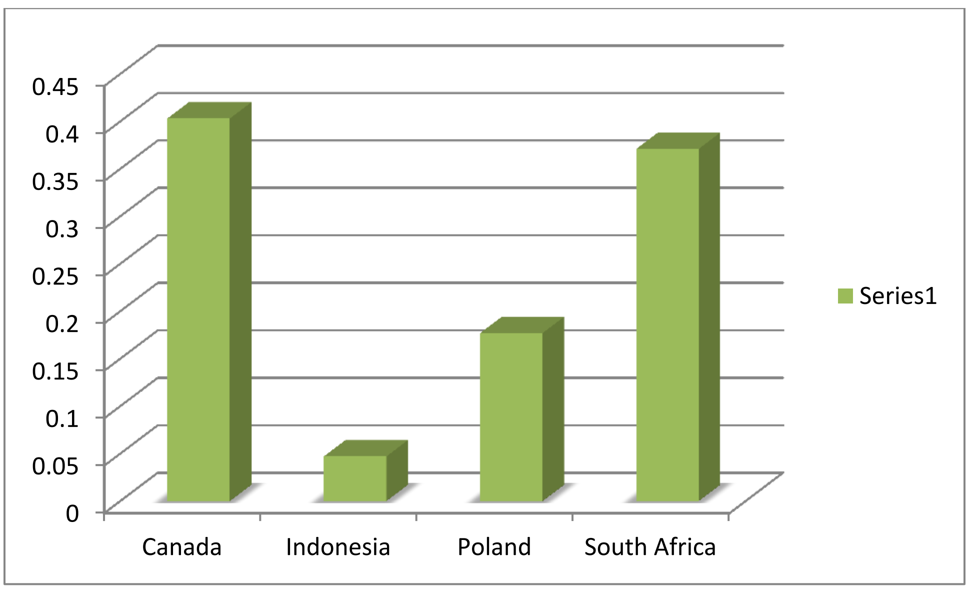


Figure 4.9: Revised Graph of Country vs Country (Industry Employment)

4.5.1.6. Coal Production

Table 4.12: Country vs Country (Coal Production)

	Canada	Indonesia	Poland	South Africa	Relative Weights	Eigenvectors M_i	λ_{max}
Canada	1	1/5	1/3	1/5	0.339	0.068	4.027
Indonesia	5	1	3	1	1.967	0.399	4.046
Poland	3	1/3	1	1/2	0.840	0.170	4.041
South Africa	5	1	2	1	1.778	0.361	4.004
Net Sum					4.924	0.998	

Mean λ_{max} = 4.029

Consistency Index (CI) = $(\lambda_{max}-n)/(n-1)$ = 0.0096

Consistency Ratio (CR) = 0.0096/0.9 = 0.01 < 0.1

Hence the pairwise comparisons are trustworthy and accepted.

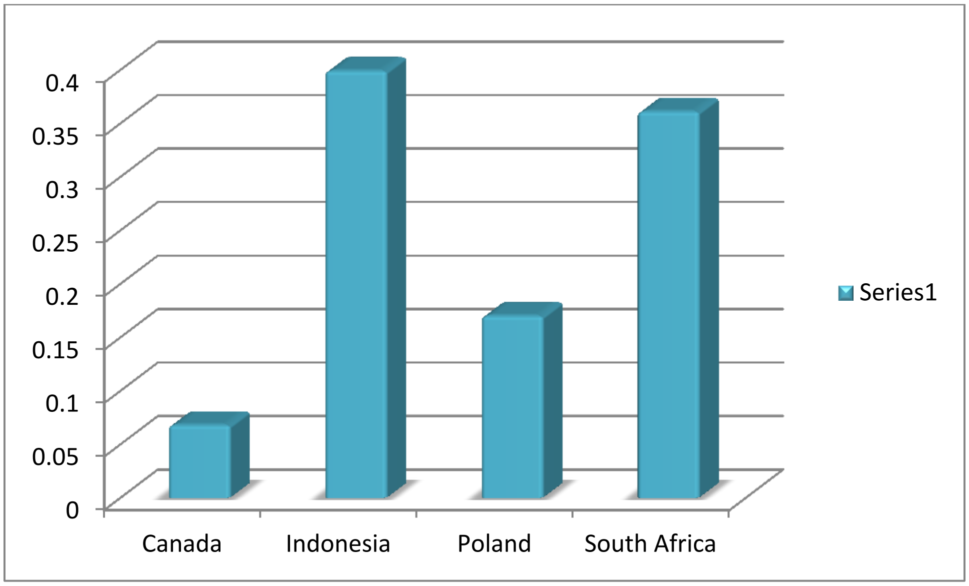


Figure 4.10: Graph of Country vs Country (Coal Production)

4.5.2 Parameters vs Parameters

In this section we weigh each of the parameters against each other. This is done to calculate and obtain a relative weight of each of them with respect to the others thereby obtaining their relative importance among the entire entire list. The pairwise comparisons have been randomly assumed in the beginning but later on their weightage is decided taking into account their precedence and importance in the mining stages.

Table 4.13: Parameters vs Parameters

	B1	B2	B3	B4	B5	B6	Relative Weights	Eigenvector K_i	λ_{max}
B1	1	3	1/3	1/7	1/5	1/3	0.4603	0.0507	7.278
B2	1/3	1	1/3	1/5	1/3	1/7	0.3192	0.0315	7.290
B3	3	3	1	1/3	1/3	1/7	1.3830	0.1524	4.02
B4	7	5	3	1	3	5	3.4109	0.3759	
B5	5	3	3	1/3	1	1/5	1.2009	0.1323	
B6	3	7	7	1/5	5	1	2.2973	0.2532	

where,

B1 – GDP/Capita

B2 – Mining Contribution to GDP

B3 – Coal Exports

B4 – Current Reserves

B5 – Industry Employment

B6 – Coal Production

The value 4.02 is < 6.00. Saaty's rule says that the eigenvectors should be greater than the order of the matrix in any case whatsoever. Hence since in this case the order of the matrix is 4 and the eigenvector obtained is 4.02 it is rejected and a new set of pairwise comparisons are chosen over the older set.

Table 4.14: Revised Parameters vs Parameters

	B1	B2	B3	B4	B5	B6	Relative Weights	Eigenvector K_i	λ_{max}
B1	1	1/3	1/3	1/5	1/7	1/9	0.2658	0.0268	6.544
B2	3	1	1/3	1/3	1/5	1/7	0.4603	0.0464	6.569
B3	3	3	1	1/5	1/7	1/9	0.5529	0.0557	6.990
B4	5	3	5	1	1/5	1/7	1.1354	0.1144	6.890
B5	7	5	6	5	1	1/3	2.7237	0.2746	6.620
B6	9	7	9	7	3	1	4.7785	0.4818	6.589

Consistency Index (CI) = $(\lambda_{max}-n)/(n-1) = 0.14$

Consistency Ratio (CR) = $0.11 \approx 0.1$ which is a just accepted value

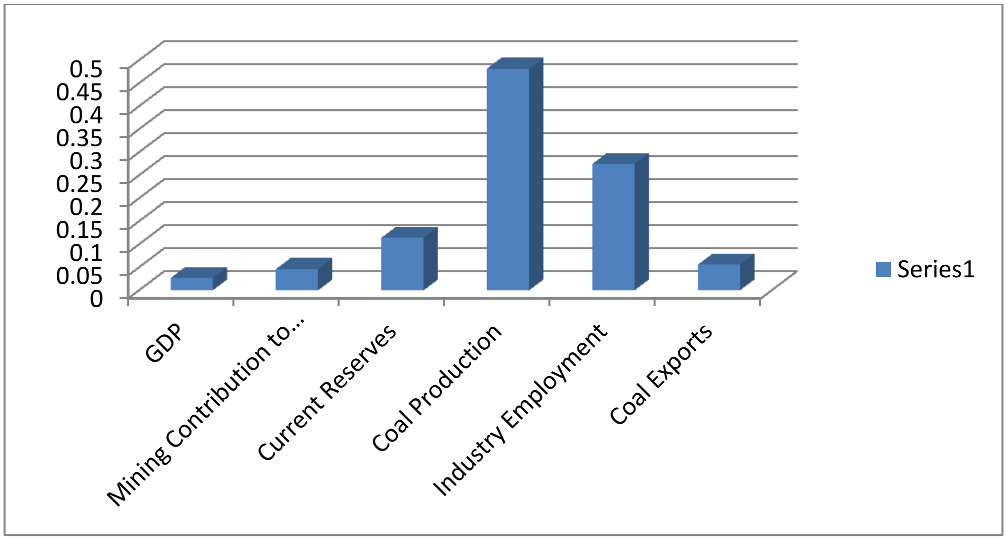


Figure 4.11: Parameters vs Parameters

4.6 Standardization of the Matrices in 4.5.1 and 4.5.2 & Calculation of Points

4.6.1 Canada

Table 4.15: Normalization Matrix of M_i and K_i (Canada)

M_i	K_i	$M_i * K_i$	Normalized Value
0.558	0.026	0.0149	0.083
0.1556	0.0464	0.0072	0.040
0.059	0.0557	0.0032	0.017
0.096	0.1144	0.0109	0.060
0.403	0.2746	0.1106	0.616
0.068	0.4818	0.0327	0.182
		0.1795	0.998

GDP = 0.083 * 39,033 = 323.9

Mining Contribution to GDP = 0.04 * 46.9 = 1.876

Coal Exports = 0.017 * 27.2 = 0.4624

Current Reserves = 0.06 * 6.578 = 0.394

Coal Production = 0.182 * 62.93 = 11.45

Industry Employment = 0.616 * 350 = 215.6

$\sum$ (Above Mentioned Parameters) = 323.9+1.876+0.4624+0.394+11.45+215.6 = 553.68 points

Hence the final obtained points for Canada turns out to be 553.68 points.

4.6.2 Indonesia

Table 4.16: Normalization Matrix of M_i and K_i (Indonesia)

M_i	K_i	$M_i * K_i$	Normalized Value
0.096	0.0268	0.0025	0.087
0.4055	0.0464	0.0188	0.0659
0.535	0.0557	0.0297	0.1042
0.249	0.1144	0.0284	0.0996
0.047	0.2746	0.0129	0.0452
0.400	0.4818	0.1927	0.076
		0.285	0.9997

GDP/Capita = 0.087 * 4380 = 38.106

Mining Contribution to GDP = 0.0659 * 10 = 0.659

Coal Exports = 0.1042 * 160.27 = 16.7

Current Reserves = 0.0996 * 17.05 = 1.69

Industry Employment = 0.0452 * 85.4 = 3.86

Coal Production = 0.676 * 233.62 = 157.92

∑ (Above Mentioned Parameters) = 38.106+0.659+16.7+1.69+3.86+157.92=218.94

Hence the final obtained points for Indonesia turns out to be 218.94 points.

4.6.3 Poland

Table 4.17: Normalization Matrix of M_i and K_i (Poland)

M_i	K_i	$M_i * K_i$	Normalized Value
0.096	0.0268	0.0025	0.0163
0.0794	0.0464	0.0036	0.0234
0.2153	0.0557	0.0119	0.0776
0.096	0.1144	0.0109	0.0711
0.177	0.2746	0.0486	0.3170
0.170	0.4818	0.0819	0.5342
		0.1533	1.01

GDP/Capita = 0.0163 * 18837= 307.04

Mining Contribution to GDP = 0.0234 * 23 = 0.538

Coal Exports = 0.0776 * 94 = 7.294

Current Reserves = 0.0711 * 7.5 = 0.533

Industry Employment = 0.317 * 119 = 37.723

Coal Production = 0.5342 * 135.14 = 72.19

∑ (Above Mentioned Parameters) = 307.04+0.538+7.294+0.533+37.723+72.19 = 425.319

Hence the final obtained points for Poland turns out to be 425.319 points.

4.6.4 South Africa

Table 4.18: Normalization Matrix of M_i and K_i (South Africa)

M_i	K_i	$M_i * K_i$	Normalized Value
0.249	0.0268	0.0066	0.0176
0.3583	0.0464	0.0166	0.0444
0.19	0.0557	0.0105	0.0281
0.557	0.1144	0.0637	0.1707
0.371	0.2746	0.1018	0.2728
0.361	0.4818	0.1739	0.4660
		0.3731	0.9996

GDP/Capita = 0.0176 * 10505 = 184.8

Mining Contribution to GDP = 0.0444 * 42.2 = 1.873

Coal Exports = 0.0281 * 63.43 = 1.782

Current Reserves = 0.1707 * 30.4 = 5.189

Industry Employment = 0.2728 * 493 = 134.49

Coal Production = 0.466 * 250 = 116.5

∑ (Above Mentioned Parameters) = 184.8+1.873+1.782+5.189+134.49+116.5 = 444.62

Hence the final obtained points for South Africa turns out to be 442.62 points.

Table 4.19: Countries vs Parameters

	GDP/Capita	Mining Contribution to GDP	Coal Exports	Current Reserves	Inudstry Employment	Coal Production
Canada	323.9	1.876	0.4624	0.394	215.6	11.45
Indonesia	38.106	0.659	16.7	1.69	3.86	157.92
Poland	307.04	0.538	7.294	0.533	37.723	72.19
South Africa	184.8	1.873	1.782	5.189	134.49	116.5

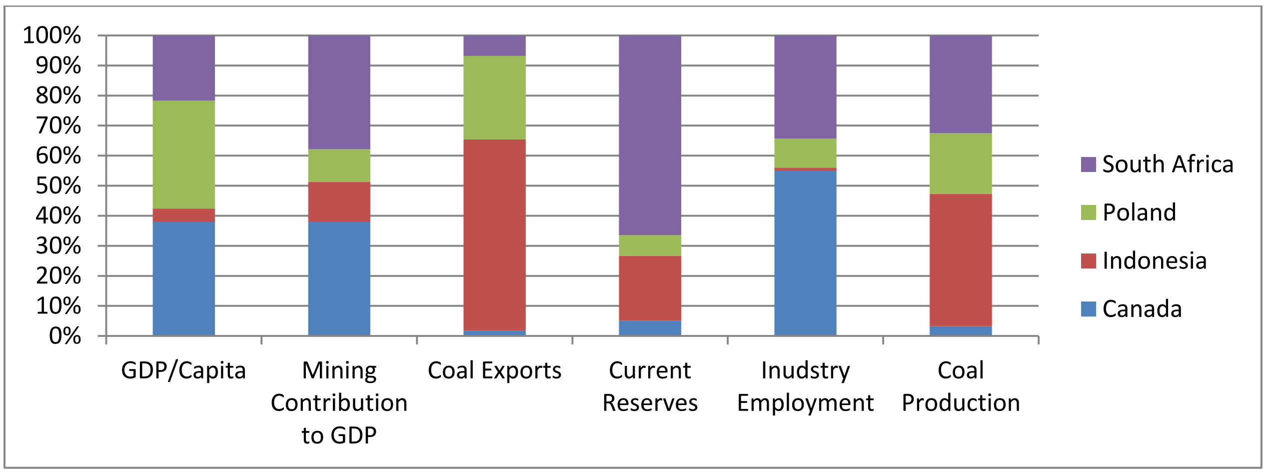


Fig. 4.12: Graph of Countries vs Parameters I

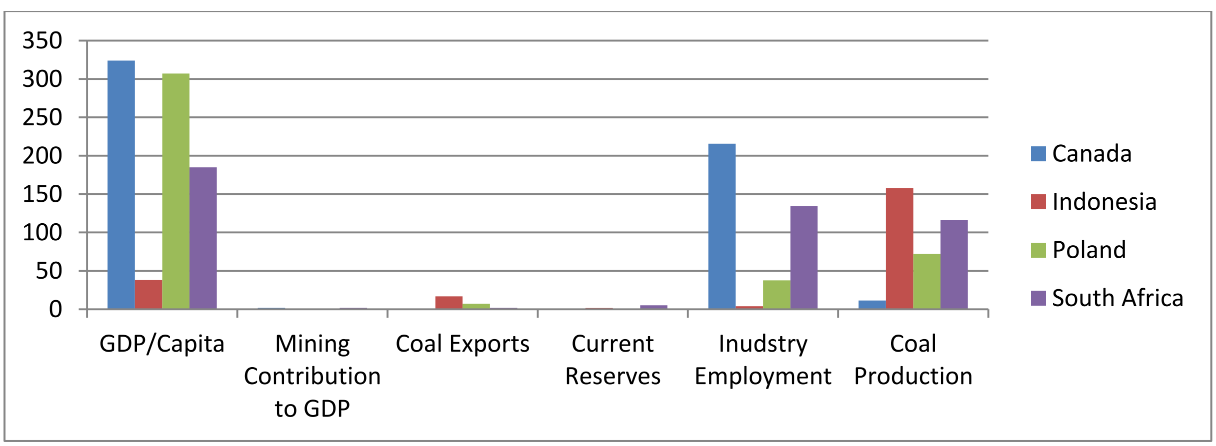


Fig. 4.13: Graph of Countries vs Parameters II

4.7 Calculation of Return of Capital

The return on capital is calculated using the following concept. Initially the capital investment in the coal mining sector of each country is taken and using forecasting we get the values for the years 2010-2012. Then each of these values is normalized using the same AHP method discussed above. Hence by this procedure we get a normalized value of capital investment as a comparison has to be done between the countries. This normalized value can further be used to get the graph between two other parameters. Then we formulate the AHP table for the coal exports from the country in the mining sector for the above years. Similarly the AHP too is implemented for this table too. We again obtain a normalized value for the exports.

Table 4.20: Country vs Country (Capital Investment)

Capital Investment	Canada	Indonesia	Poland	South Africa	Relative Weights	Eigenvector	λ_{max}
Canada	1	1/3	2	2	1.074	0.208	4.292
Indonesia	3	1	5	5	2.942	0.572	4.005
Poland	1/2	1/5	1	1	0.562	0.109	4.002
South Africa	1/2	1/5	1	1	0.562	0.109	4.002
Net Sum					5.14	0.998	

Mean λ_{max} = 4.075

Consistency Index (CI) = (4.075-4)/ (4-1) = 0.025

Consistency Ratio (CR) = 0.025/0.9 = 0.02 < 0.1 and hence it is consistent.

Now for the calculation we first calculate the coal exports costs of the various countries from the years 2006-2012. The values for 2006-2009 have been obtained from various sources and organization whereas the values for the other 3 years have been forecasted. The international coal prices have been taken for the previous years and the value obtained after multiplying with exports minus the total capital investment gives the value of the return on capital.

4.7.1 Coal Prices

Coal Prices have been consistently varying over the past few years. From 2006-2012 we can see a wide variation in the price of coal. This can be attributed largely to the economic changes happening all over the world. From the economic slump to the expansion of industries each and every factor has strongly fuelled the rise in the price of this commodity. Coal prices started from 70.93US$/ton in 2006 and increasing up to 118 US$/ton in 2010. The values for the next few years have been forecasted [15].

Table 4.21 Coal Prices (2006-2012)

Year	Coal Price (US$/ton)
2006	70.93
2007	70.25
2008	97.68
2009	101.63
2010	118.43
2011	129.69
2012	142.33

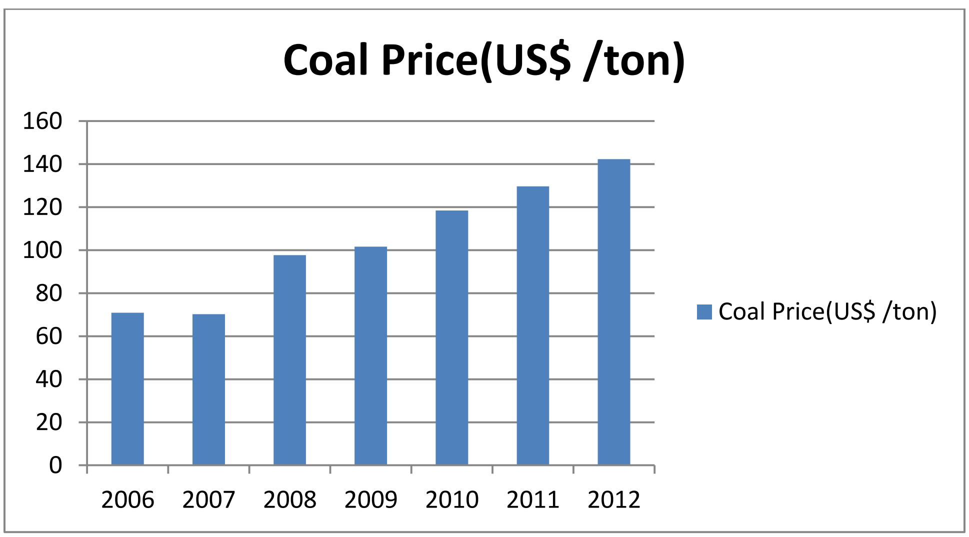


Fig 4.14: Coal Prices (2006-2012)

4.7.2 Canada

Table 4.22: Table for Returns (Canada)

Year	Capital Investment (billion $)	Normalized Capital Investment	Exports Value (billion US$)	Normalized Exports	Return (billion US$)
2006	0.4	0.0832	2.2158532	0.130735339	0.047535339
2007	0.5	0.104	2.3976325	0.141460318	0.037460318
2008	0.8	0.1664	3.5692272	0.210584405	0.044184405
2009	0.5	0.1456	3.7135602	0.219100052	0.073500052
2010	0.7	0.1456	4.09720428	0.241735053	0.096135053
2011	0.76	0.15808	4.5443376	0.268115918	0.110035918
2012	0.82	0.17056	5.052928	0.298122752	0.127562752

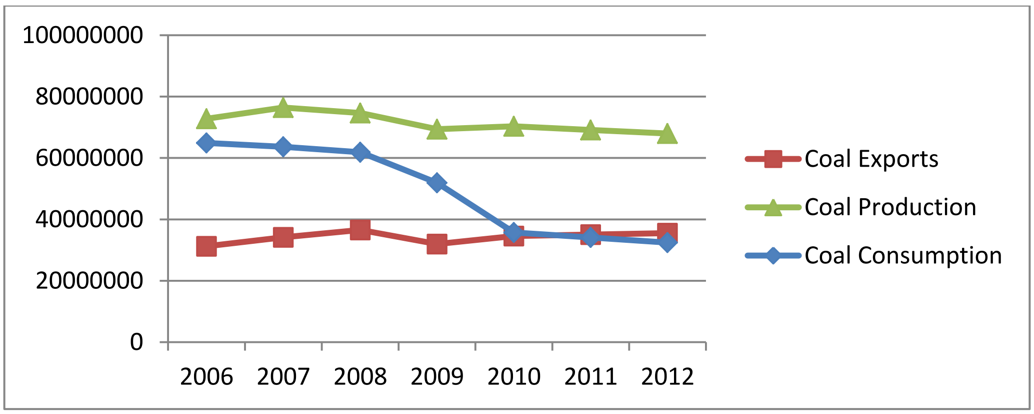


Fig 4.15: Figure for Production, Consumption and Exports (Canada)

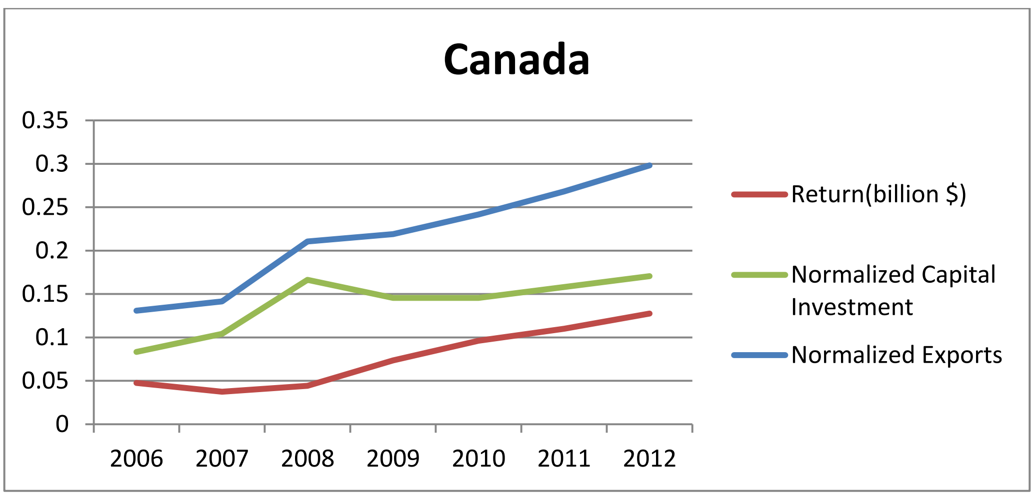


Fig 4.16: Return on Capital (Canada)

4.7.3 Indonesia

Table 4.23: Table for Returns (Indonesia)

Year	Capital Investment (billion $)	Normalized Capital Investment (billion $)	Export Value (billion US$)	Normalized Exports	Return (billion US$)
2006	1.127	0.572	13.634668	7.29454738	6.72254738
2007	1.18	0.67496	15.58531375	8.338142856	7.663182856
2008	1.435	0.82082	22.603152	12.09268632	11.27186632
2009	1.555333333	0.889650667	26.566082	14.21285387	13.3232032
2010	3.1	1.7732	31.38395	16.79041325	15.01721325
2011	2.975866667	1.702195733	37.597131	20.11446509	18.41226935
2012	3.408	1.949376	43.839488	23.45412608	21.50475008

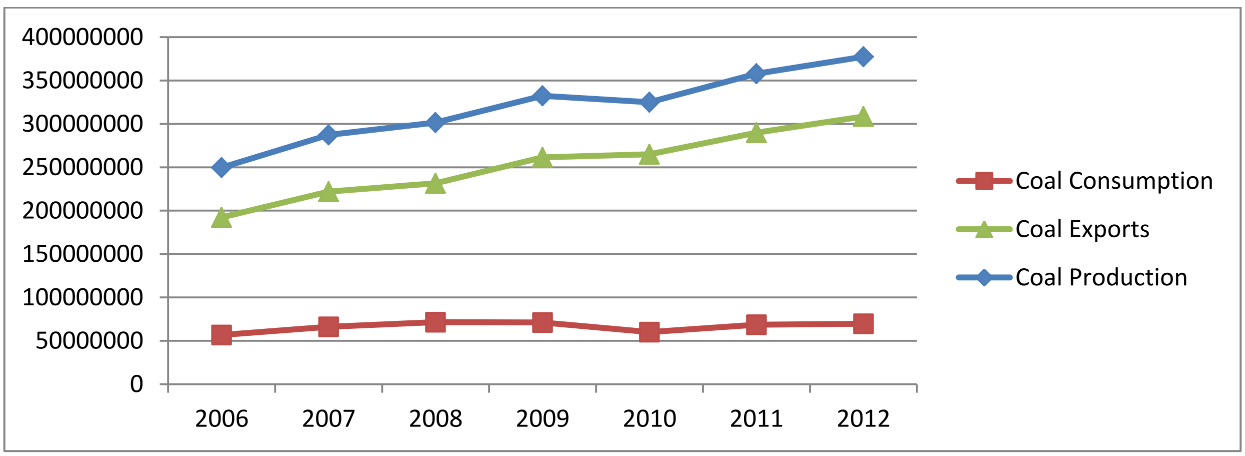


Fig 4.17: Figure for Production, Consumption and Exports (Indonesia)

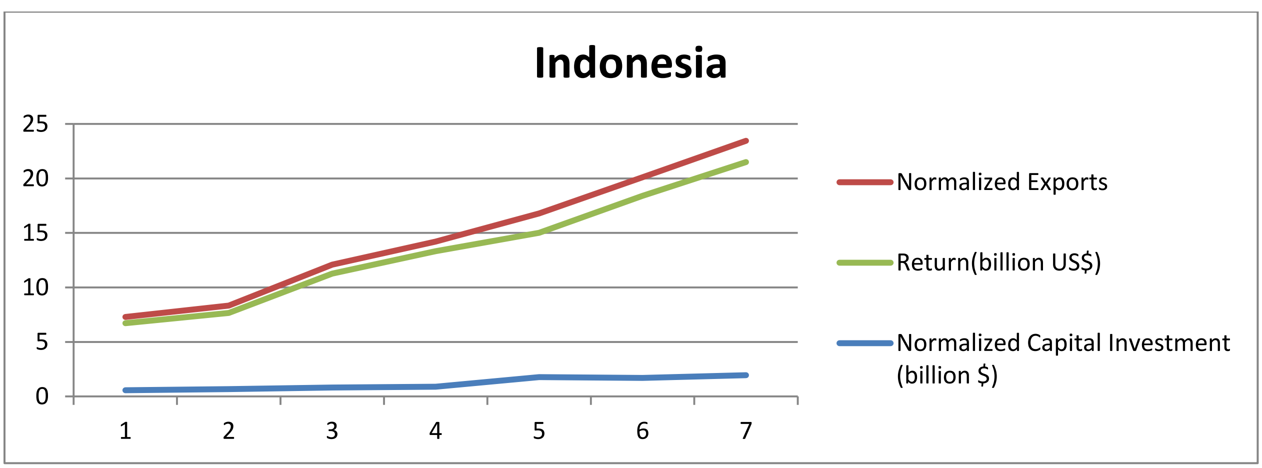


Fig 4.18: Return on Capital (Indonesia)

4.7.4 South Africa

Table 4.24: Table for Returns (South Africa)

Year	Capital Investment (billion $)	Normalized Capital Investment	Exports(billion US$)	Normalized Exports	Returns
2006	1.988	0.216692	5.369401	1.02018619	0.80349419
2007	2.49	0.27141	5.10050125	0.969095238	0.697685238
2008	2.58	0.28122	6.4600668	1.227412692	0.946192692
2009	2.23	0.24307	7.49694021	1.42441864	1.18134864
2010	2.526	0.275334	8.16503792	1.551357205	1.276023205
2011	2.6076	0.2842284	8.7787161	1.667956059	1.383727659
2012	2.6892	0.2931228	9.45680384	1.79679273	1.50366993

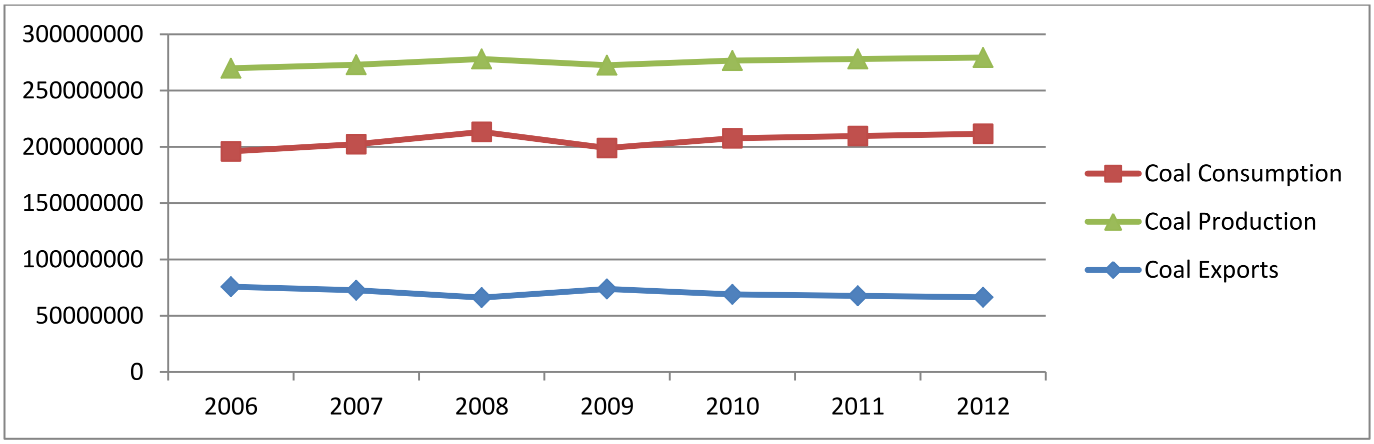


Fig 4.19: Figure for Production, Consumption and Exports (South Africa)

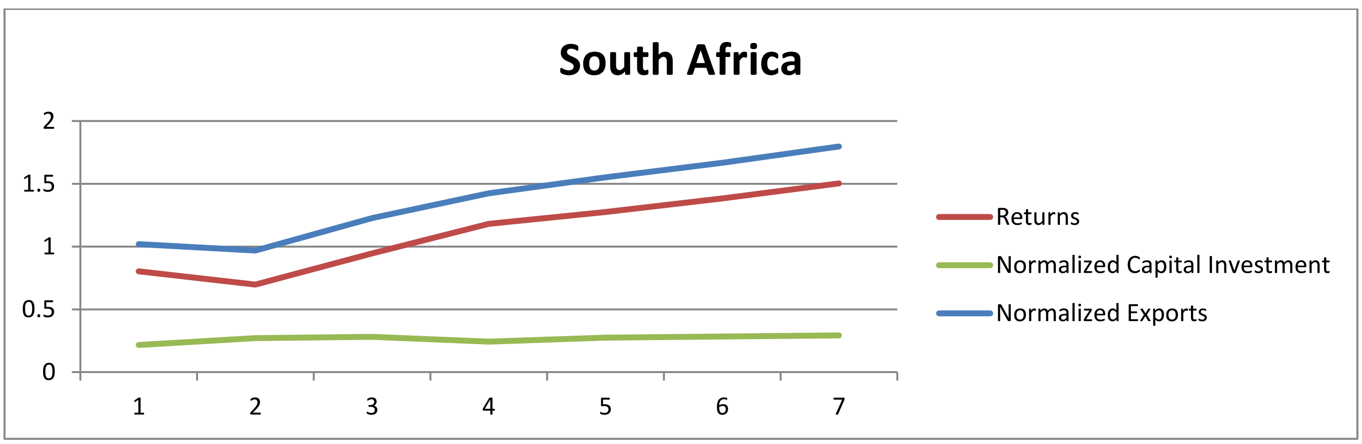


Fig 4.20: Return on Capital (South Africa)

Chapter 5

RESULTS AND DISCUSSIONS

5.1 RESULTS

The hierarchy of different countries and their total points obtained are as follows:

The total points obtained for **Canada** is **553.68**.

The total points obtained for **South Africa** is **444.62**.

The total points obtained for **Poland** is **425.319**

The total points obtained for **Indonesia** is **218.94**.

The return on capital was found to be maximum for **Indonesia** followed by **South Africa** and then **Canada** (Poland was not included in this part of the study as certain figures for Poland were not available).

5.2 DISCUSSIONS

The AHP analysis of the four countries showed that the values and points obtained for each of them vary with their actual standard as developing and developed countries. Canada for example is a developed country according to its actual GDP and economy and hence the points obtained for Canada are significantly higher than obtained for the other three countries. Having a relatively stable economy in the world it is expected to be higher than the other developing countries taken for consideration and this has been obtained from the calculations shown in the previous sections. A margin of over 100 points ahead of South Africa shows that mining sectors prevalent in or near the United States tend to perform better than the countries in the African region.

This can be extended to other parts of the world too. However certain anomalies can be observed. We can see that for Poland which comes in Europe is expected to perform better than the African country but it doesn’t happen so. Poland tends to perform relatively as good as South Africa but does fall behind ultimately. Countries which belong to regions of better economic performance may not necessarily perform better than those which belong to regions of lower economic performance. Though Europe seems to be doing better than Africa as a region however South Africa tends to perform better in the mining scenario as compared to Poland.

Similarly we can see that though Asia seems to perform better as compared to African or European economies but still Indonesia is lacking behind these as far as the mining sector is concerned. Hence we see that a region's performance may not necessarily be linked with a particular country's performance with the countries of other regions. This further supports the comments made in the previous paragraph.

Moreover it is seen that the statistics and calculation have been done taken only coal into account as the mineral concerned. If other natural resources are taken into consideration then the points may tend to vary due to certain countries having abundance of different deposits/resources. Hence the above results are restricted to only coal mining. However it gives more or less an idea about the performance of that country as far as the utilization of natural resources are concerned.

For the return on capital it can be seen that Indonesia has a higher return on capital as compared to Canada and South Africa. South Africa has a higher return on capital against Canada. Although Canada posts a better score in the rating it does not perform well in the return section because the coal exports of coal as comparatively lesser as compared to other countries like Indonesia and South Africa. Likewise though Indonesia performs the worst in the rating it happens to get the highest return on capital as majority of its coal is exported and hence contributes to its earnings.

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